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Monks et al.

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(45) **Date of Patent: Apr. 17, 2007**

(54) **AUTOMATED SOUND SYSTEM DESIGNING**

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G06F 17/00 (2006.01)

(52) **U.S. Cl.** **381/58**; 700/94

(58) **Field of Classification Search** 381/103, 381/61, 58–59; 700/94; 715/727; 84/601, 84/604, 609; 704/272
See application file for complete search history.

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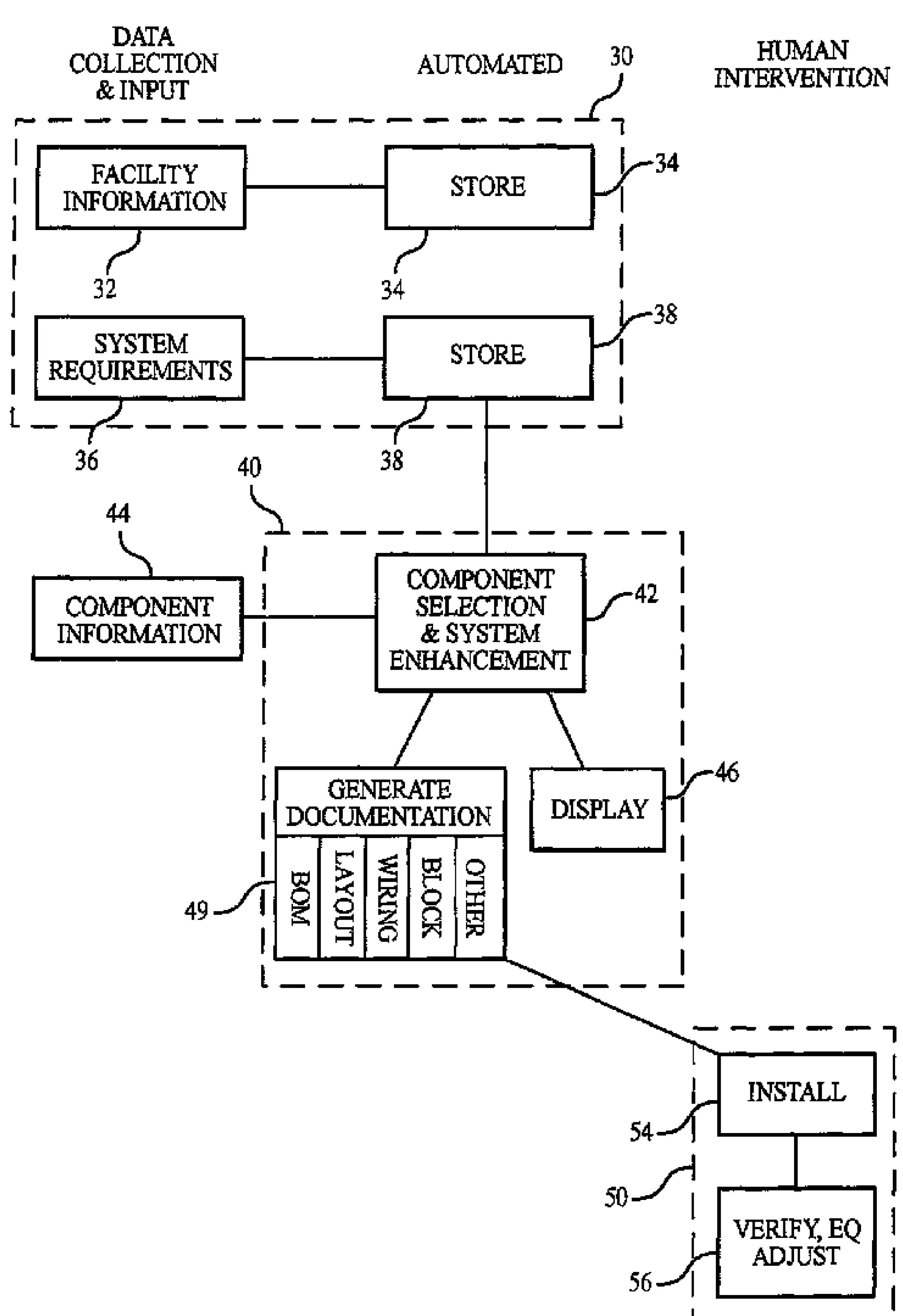
(57) **ABSTRACT**

An automated sound system design device and a method for operating it. A computer is constructed and arranged to accept input of facility information signals and sound system preference signals requirements, and using a previously stored assemblage of component performance capability data signals to generate a sound system output signal configuration, representative of a desired sound system.

8 Claims, 9 Drawing Sheets



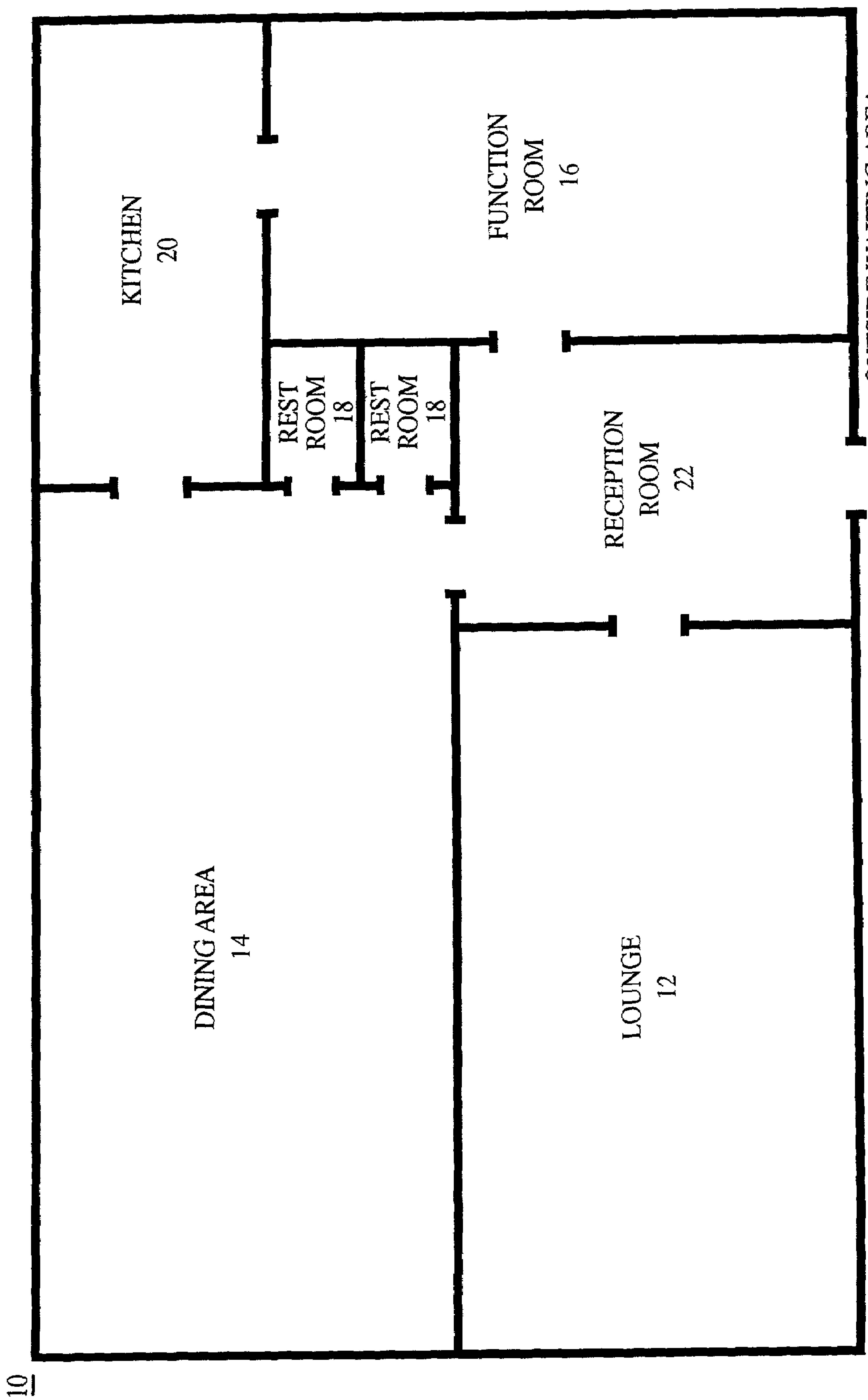

KITCHEN
20
FUNCTION
ROOM
16
OUTSIDE WAITING AREA
24
REST
ROOM
18
REST
ROOM
18
RECEPTION
ROOM
22
DINING AREA
14
LOUNGE
12
10

FIG. 1

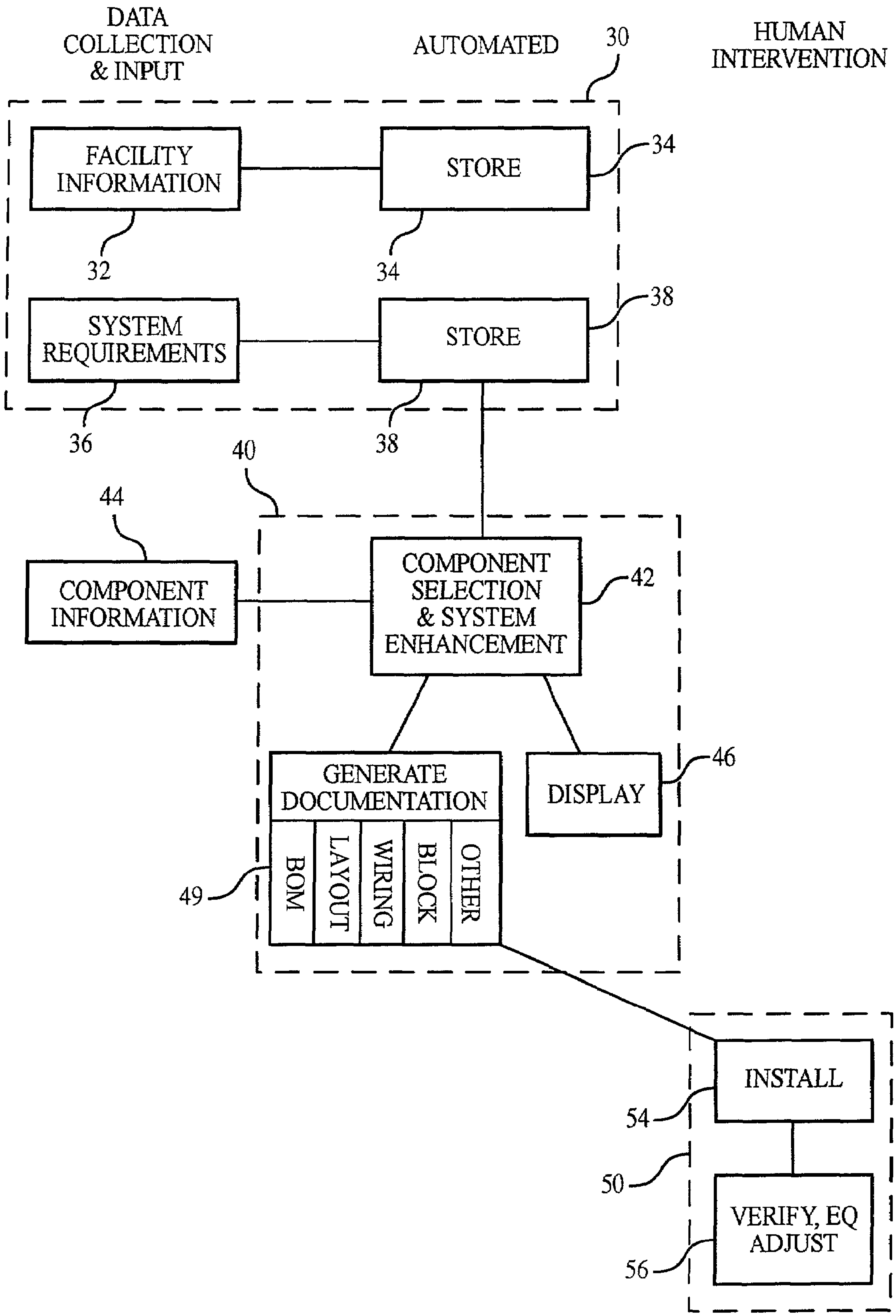
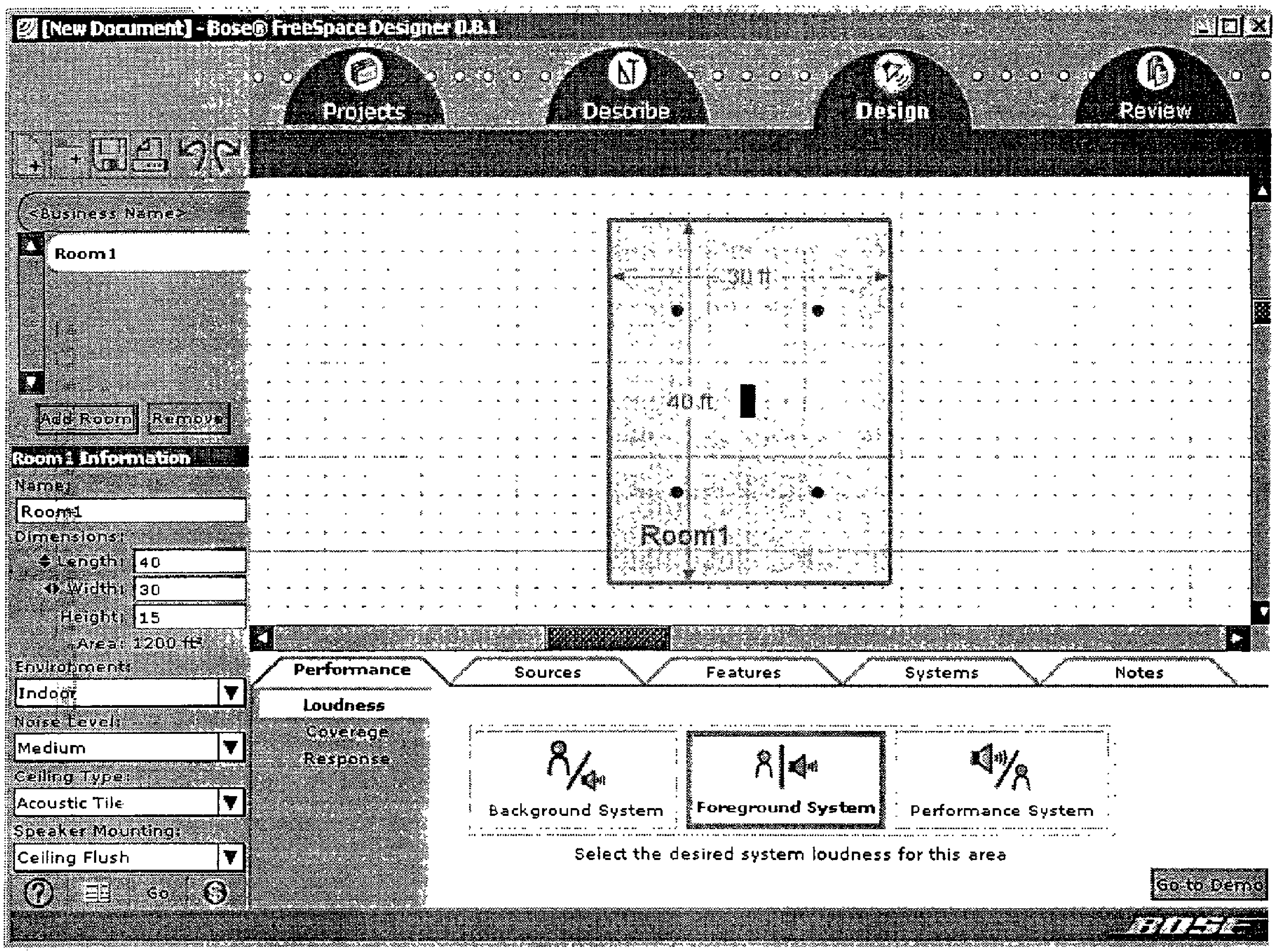

DATA COLLECTION & INPUT
AUTOMATED
HUMAN INTERVENTION
30
FACILITY INFORMATION
32
STORE
34
34
SYSTEM REQUIREMENTS
36
STORE
38
38
40
44
COMPONENT INFORMATION
COMPONENT SELECTION & SYSTEM ENHANCEMENT
42
GENERATE DOCUMENTATION
BOM
LAYOUT
WIRING
BLOCK
OTHER
49
DISPLAY
46
INSTALL
54
50
VERIFY, EQ ADJUST
56

FIG. 2


[New Document] - Bose® FreeSpace Designer 0.8.1
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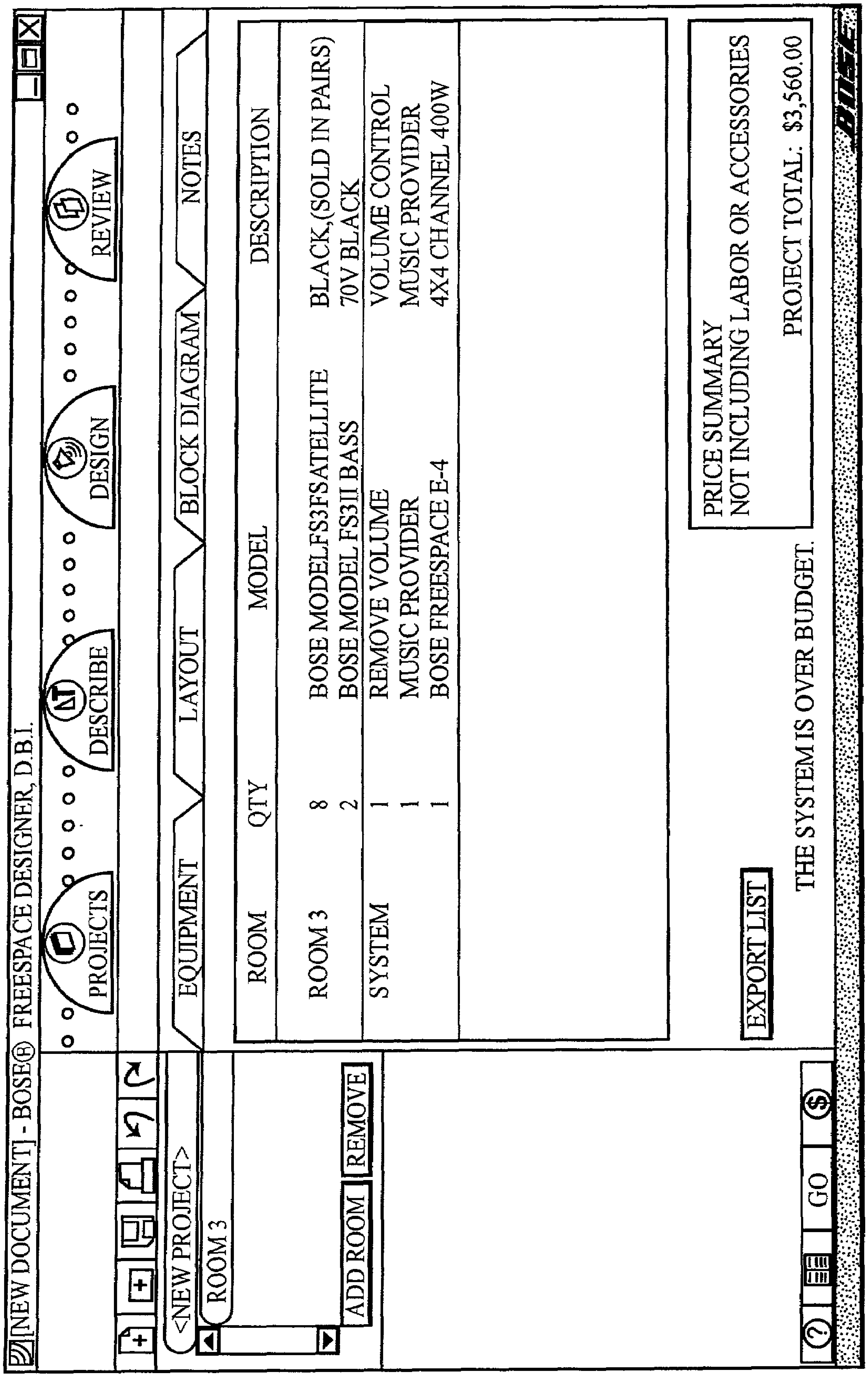
Design
Review
<Business Name>
Room1
Add Room
Remove
Room 1 Information
Name:
Room1
Dimensions:
Length: 40
Width: 30
Height: 15
Area: 1200 ft²
Environment:
Indoor
Noise Level:
Medium
Ceiling Type:
Acoustic Tile
Speaker Mounting:
Ceiling Flush
30 ft
40 ft
Room1
Performance
Sources
Features
Systems
Notes
Loudness
Coverage
Response
Background System
Foreground System
Performance System
Select the desired system loudness for this area
Go to Demo
BOSE

FIG. 3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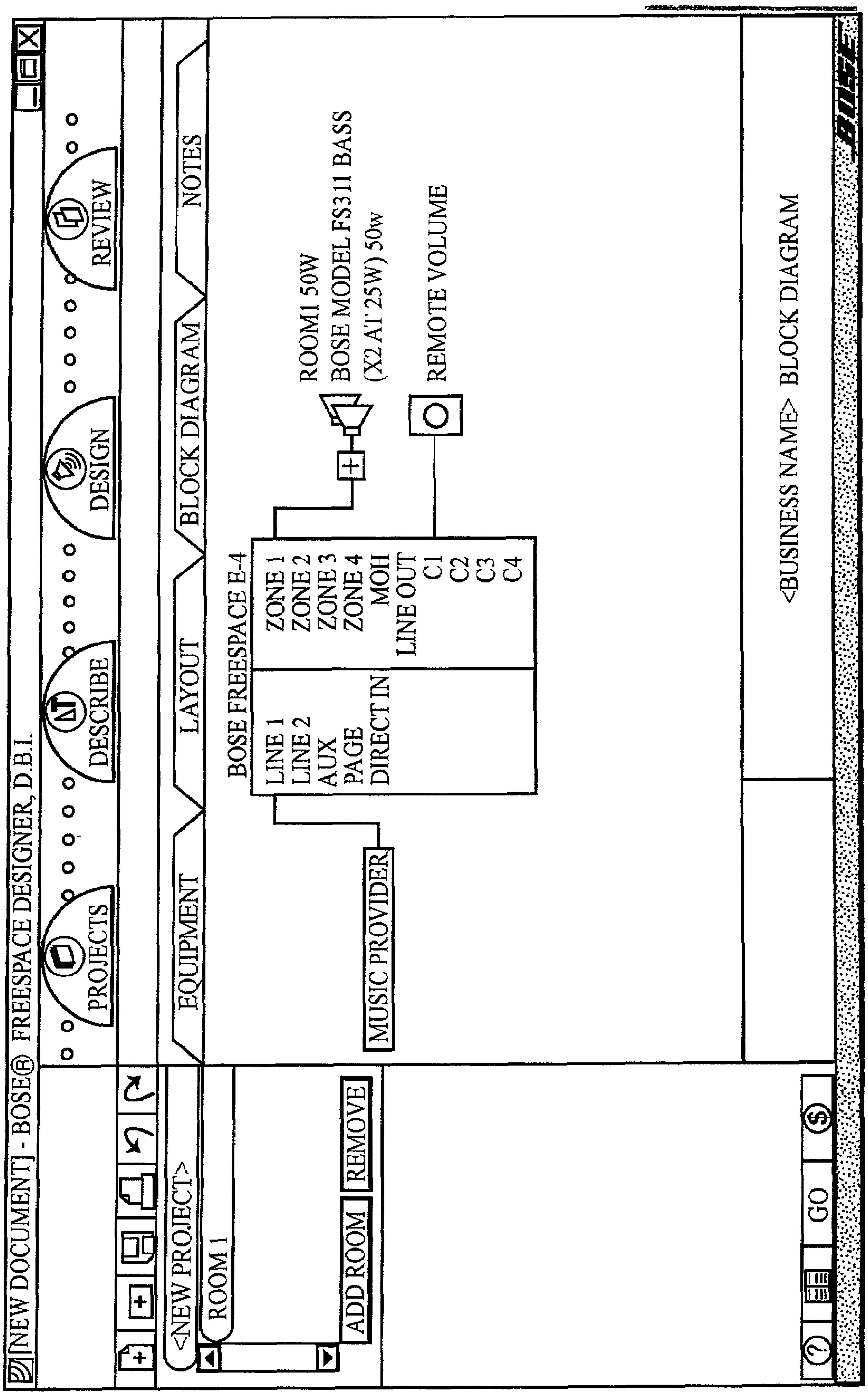
PROJECTS
DESCRIBE
DESIGN
REVIEW
<NEW PROJECT>
ROOM 3
ADD ROOM
REMOVE
EQUIPMENT
LAYOUT
BLOCK DIAGRAM
NOTES
ROOM
QTY
MODEL
DESCRIPTION
ROOM 3
8
BOSE MODELFS3FSATELLITE
BLACK,(SOLD IN PAIRS)
2
BOSE MODEL FS3II BASS
70V BLACK
SYSTEM
1
REMOVE VOLUME
VOLUME CONTROL
1
MUSIC PROVIDER
MUSIC PROVIDER
1
BOSE FREESPACE E-4
4X4 CHANNEL 400W
EXPORT LIST
THE SYSTEM IS OVER BUDGET.
PRICE SUMMARY
NOT INCLUDING LABOR OR ACCESSORIES
PROJECT TOTAL: $3,560.00
GO
BOSE

FIG. 4a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REVIEW
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ROOM 1
ADD ROOM
REMOVE
EQUIPMENT
LAYOUT
BLOCK DIAGRAM
NOTES
MUSIC PROVIDER
BOSE FREESPACE E-4
LINE 1
LINE 2
AUX
PAGE
DIRECT IN
ZONE 1
ZONE 2
ZONE 3
ZONE 4
MOH
LINE OUT
C1
C2
C3
C4
ROOM1 50W
BOSE MODEL FS311 BASS
(X2 AT 25W) 50w
REMOTE VOLUME
<BUSINESS NAME> BLOCK DIAGRAM
GO
BOSE

FIG. 4b

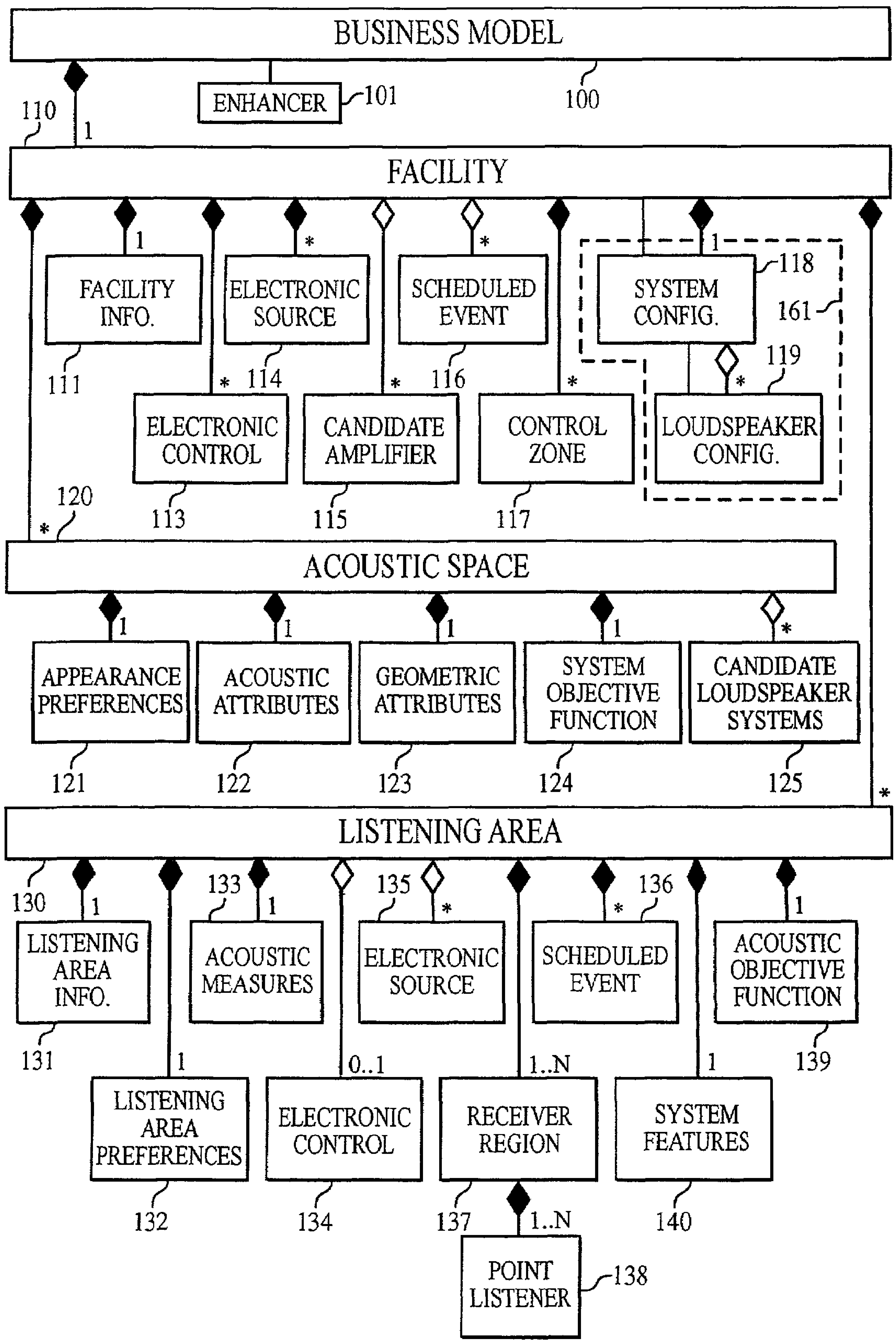

BUSINESS MODEL
ENHANCER
101
100
110
1
FACILITY
1
*
*
1
FACILITY INFO.
ELECTRONIC SOURCE
SCHEDULED EVENT
SYSTEM CONFIG.
118
161
119
111
114
116
*
*
*
*
ELECTRONIC CONTROL
CANDIDATE AMPLIFIER
CONTROL ZONE
LOUDSPEAKER CONFIG.
120
*
113
115
117
ACOUSTIC SPACE
1
1
1
1
*
APPEARANCE PREFERENCES
ACOUSTIC ATTRIBUTES
GEOMETRIC ATTRIBUTES
SYSTEM OBJECTIVE FUNCTION
CANDIDATE LOUDSPEAKER SYSTEMS
121
122
123
124
125
*
LISTENING AREA
130
1
133
1
135
*
*
136
1
LISTENING AREA INFO.
ACOUSTIC MEASURES
ELECTRONIC SOURCE
SCHEDULED EVENT
ACOUSTIC OBJECTIVE FUNCTION
131
1
0..1
1..N
1
139
LISTENING AREA PREFERENCES
ELECTRONIC CONTROL
RECEIVER REGION
SYSTEM FEATURES
132
134
137
1..N
140
POINT LISTENER
138

FIG. 5a

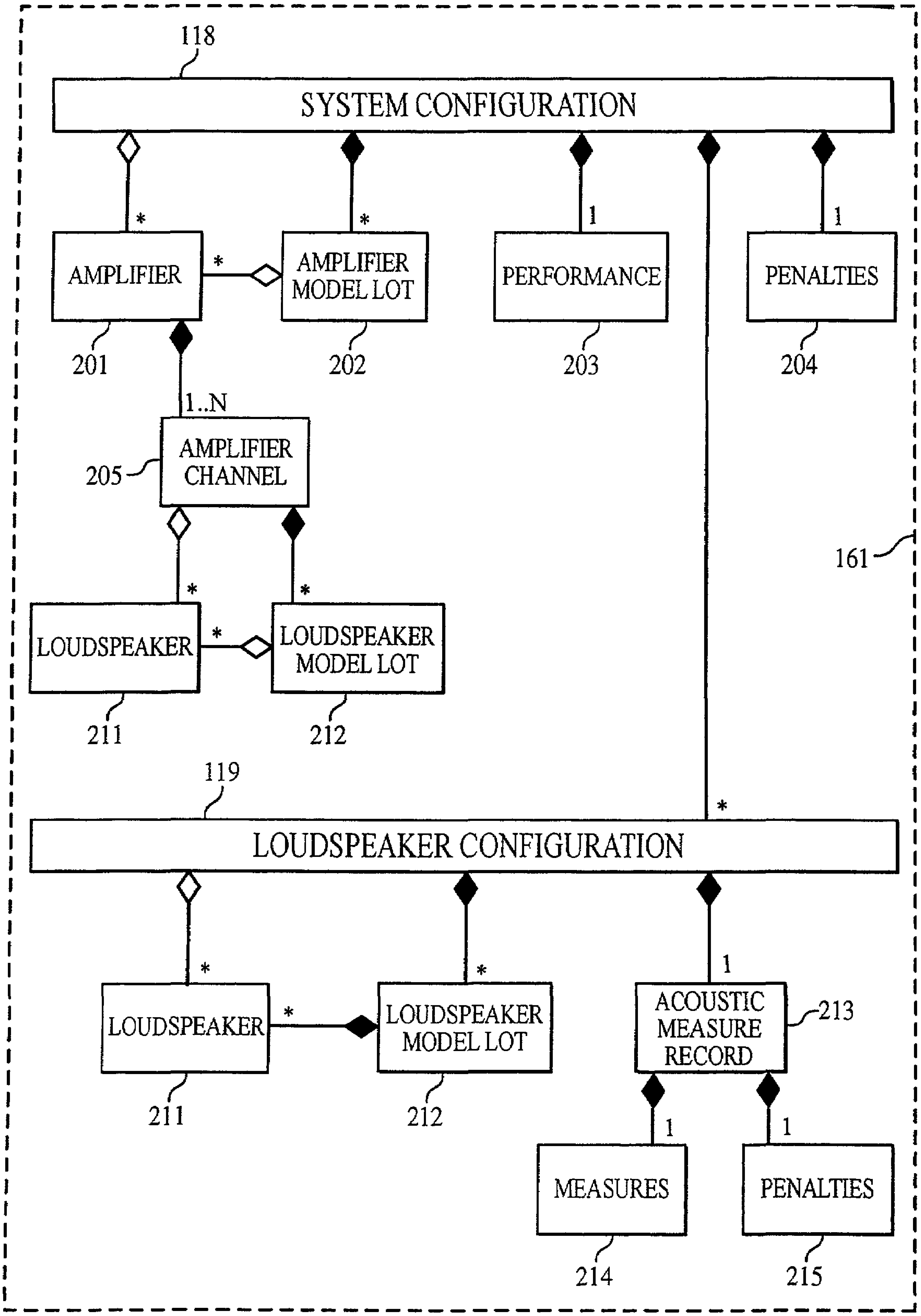

118
SYSTEM CONFIGURATION
*
*
1
1
AMPLIFIER
*
AMPLIFIER MODEL LOT
PERFORMANCE
PENALTIES
201
202
203
204
1..N
205
AMPLIFIER CHANNEL
*
*
161
LOUDSPEAKER
*
LOUDSPEAKER MODEL LOT
211
212
119
*
LOUDSPEAKER CONFIGURATION
*
*
1
LOUDSPEAKER
*
LOUDSPEAKER MODEL LOT
ACOUSTIC MEASURE RECORD
213
211
212
1
1
MEASURES
PENALTIES
214
215

FIG. 5b

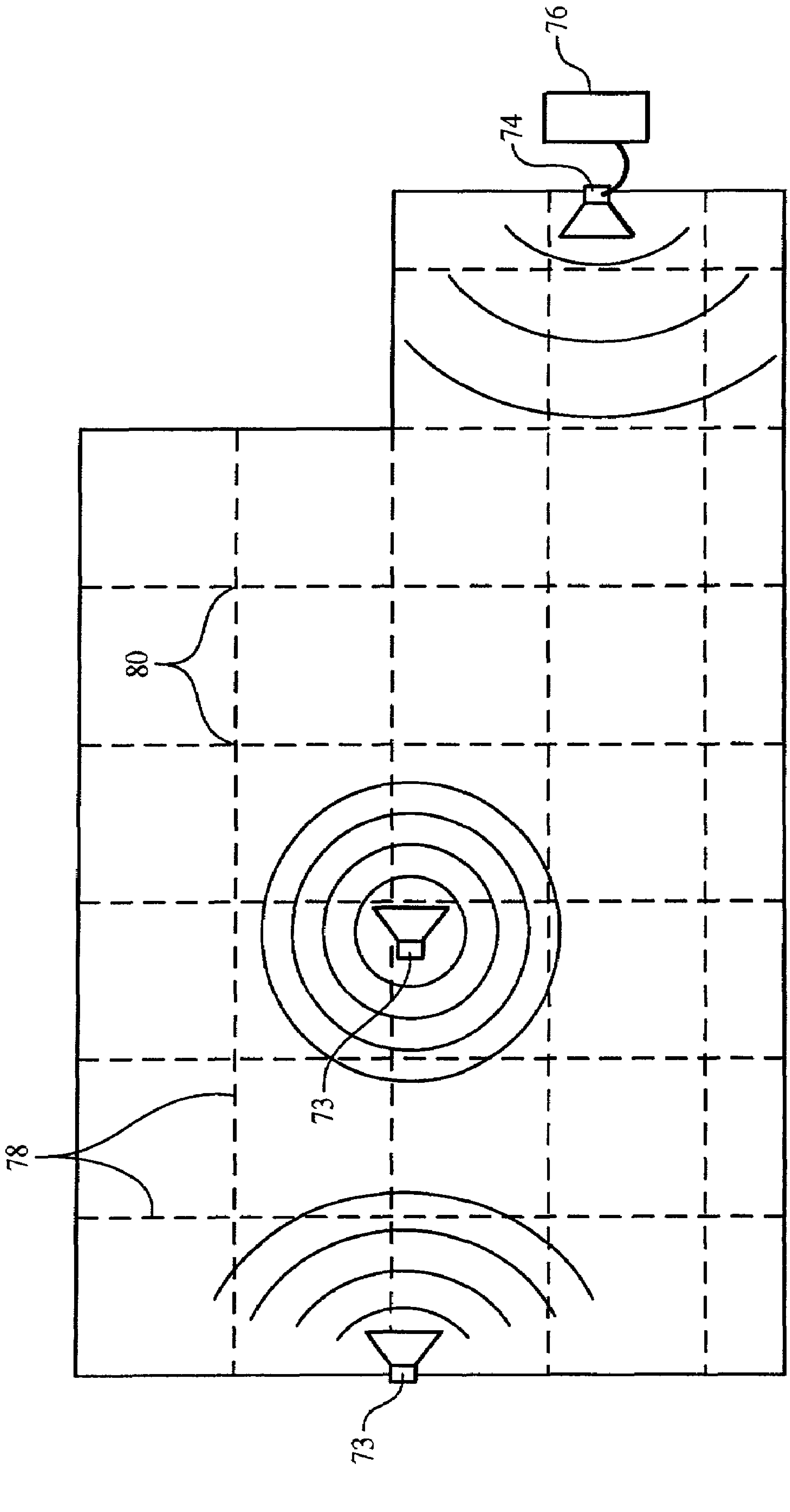
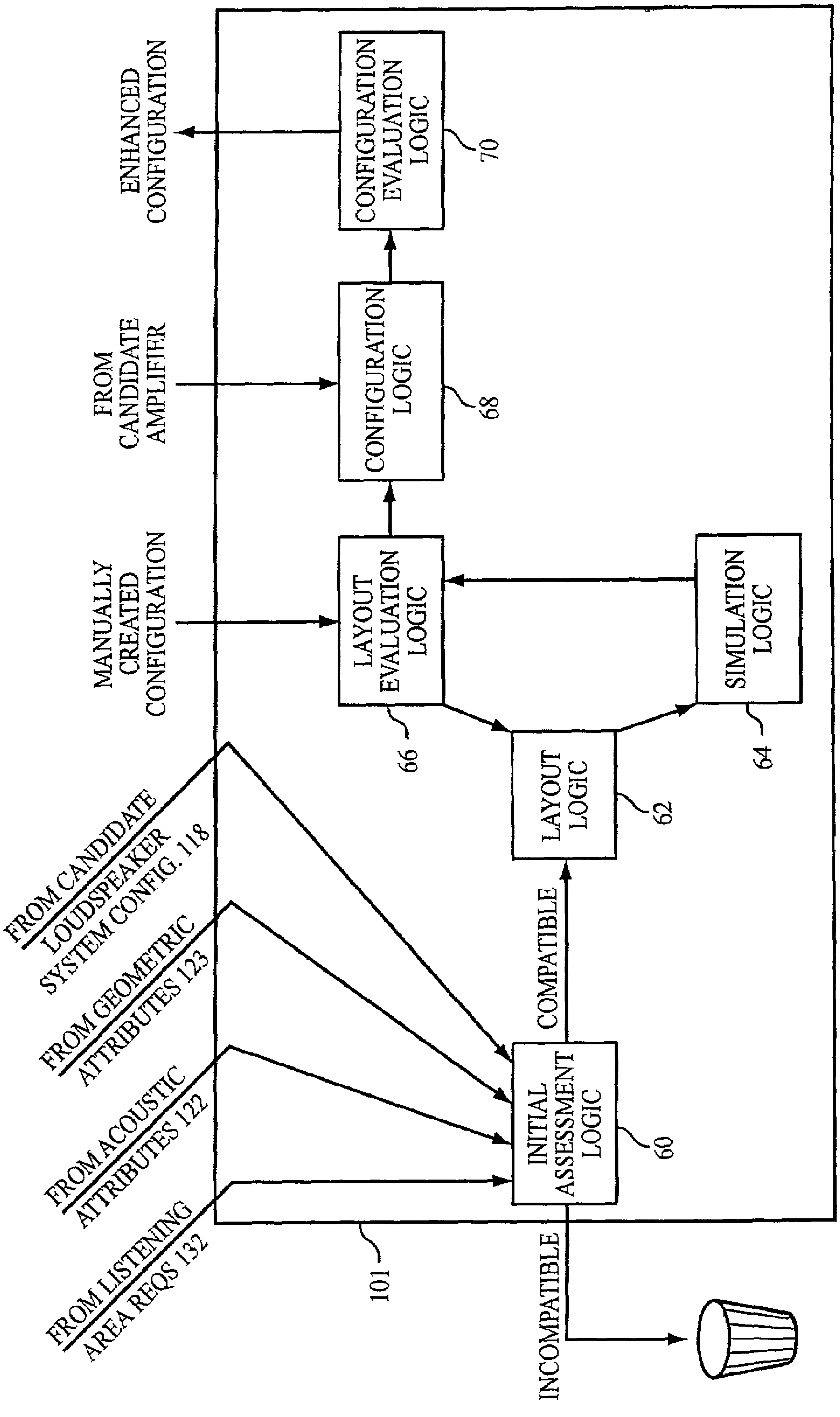


FIG. 6



ENHANCED CONFIGURATION
FROM CANDIDATE AMPLIFIER
MANUALLY CREATED CONFIGURATION
CONFIGURATION EVALUATION LOGIC
70
CONFIGURATION LOGIC
68
LAYOUT EVALUATION LOGIC
66
SIMULATION LOGIC
64
LAYOUT LOGIC
62
FROM CANDIDATE LOUDSPEAKER SYSTEM CONFIG. 118
FROM GEOMETRIC ATTRIBUTES 123
FROM ACOUSTIC ATTRIBUTES 122
FROM LISTENING AREA REQS 132
COMPATIBLE
INITIAL ASSESSMENT LOGIC
60
101
INCOMPATIBLE

FIG. 7

AUTOMATED SOUND SYSTEM DESIGNING

The invention to the design of sound system for commerical establishments, and more particularly to an automated method for designing sound systems.

BACKGROUND OF THE INVENTION

It is an important object of the invention to provide an improved method for designing sound systems.

BRIEF SUMMARY OF THE INVENTION

According to the invention, a method for designing a sound system for a facility includes inputting performance data signals representing desired performance properties for the sound system to a computer processor; inputting acoustic data signals representing acoustic characteristics of acoustic spaces in the facility to the computer processor; comparing, by the processor, the acoustic data signals and the performance data signals with a preexisting data base of sound equipment component capability signals; and generating, by the processor in real time, output configuration signals for the sound system, the sound system including loudspeakers and amplifiers.

In another aspect of the invention, an apparatus for designing a sound system for a facility includes a memory, for storing data signals representing sound system component properties; and a computer processor, coupled to the memory, constructed and arranged to accept as input data information signals including desired sound system performance capability signals. The input data signals also include acoustic signals characteristics of the facility. The computer processor is constructed and arranged to generate in real time, based on the acoustic characteristic signals and the desired sound system performance capability signals sound system configuration output signals representative of components and interconnections between the components.

Other features, objects, and advantages will become apparent from the following detailed description, when read in connection with the accompanying drawing in which:

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWING

FIG. **1** is a floor layout useful in explaining aspects of the invention;

FIG. **2** is a block diagram of a process for designing a sound system for a facility such as in FIG. **1** and described in the accompanying section of the disclosure;

FIG. **3** is a depiction of a graphical user interface for inputting data and for displaying aspects of the invention;

FIGS. **4***a* and **4***b* are depictions of a display on a computer monitor;

FIGS. **5***a* and **5***b* show a class of diagrams describing the architecture of a computer program according to the invention;

FIG. **6** is a diagrammatic view of floor layout useful in explaining aspects of the invention; and

FIG. **7** is a block diagram illustrating the logical arrangement of the enhancer.

DETAILED DESCRIPTION

With reference now to the drawing and more particularly to FIG. **1**, to illustrate the purpose of the invention, there is shown a simplified floor plan of an exemplary restaurant. Restaurant **10** includes a number of separate areas, each having different needs for the sound system, such as in terms of sound source, music genre, and loudness desired. For example, lounge area **12** may be equipped with a large screen television and several monitors, and may need to accept as input sound from a DVD and CD player, or a cable or satellite TV broadcast. The sound may be used as background music or for the audio portion of a television broadcast. The volume is preferably automatically adjustable by the sound system so that it is not too loud when the lounge is relatively quiet, but is audible when the ambient noise is high, when, for example a large crowd is watching the broadcast of a sporting event. The sound in dining area **14** may be primarily for background music, with the source a CD changer. The volume in the dining area is preferably automatically adjustable, but the maximum volume may not need to be as high as in the lounge area, because the maximum ambient noise may be less. Function room **16** may be a versatile area, so that it can be used as an auxiliary dining area having the same sound needs as dining area **14**. Additionally, function room **16** may be able to accommodate meetings requiring foreground speech audibility, and for entertainment, so that the music is foreground as well as background and automatically adjustable volume, with a higher maximum volume than in dining area **14**. Function room **16** may also be equipped for large screen television broadcasts, as in lounge area **12**. Restrooms **18** may only furnish background music from the same source as for dining area **14**, but may not be automatically adjustable volume nor as high a maximum volume as in dining room **14**. All areas of the restaurant, including kitchen **20** may be constructed and arranged to broadcast audible alarms from an automated alarm source and pages at an appropriate level. It may be desirable for a host or hostess in reception area **22** to be able to broadcast a page to patrons in the lounge area **12** (for example patrons awaiting a table in the dining area) or to an outdoor waiting area **24** without broadcasting the page to the dining area **14**.

There follows definition of a number of terms. A facility includes an entire building, or major portion of a building, to be serviced by the sound system. In the above example, restaurant **10** is a facility. An acoustic space is a contiguous portion of a facility that has common acoustic properties (for example reverberation characteristics). Acoustic properties are typically the result of room geometry (including ceiling height), floor treatment, wall treatment, windows and window treatment, and the like. In the example above, the dining room **14**, the function room **16**, and the combined lounge **12** and reception area **22** may each be acoustic spaces. A listening area is a portion of the facility that has a common set of sound system requirements, such as maximum and minimum sound pressure level, frequency response, similar importance of speech band and music band. An acoustic space and a listening area may be coincident as they are in this example. In other situations, a single acoustic space may contain multiple listening areas. For example, if there were no wall between the lounge and reception area **22**, the lounge and reception area could be a single acoustic space with two different listening areas. A zone is a portion of the facility which may be noncontiguous, but which is serviced by a common amplifier channel. For example, the two restrooms **18** may be a zone, and the dining room, reception area, and function room may be acoustic spaces, listening areas, and zones.

Referring now to FIG. **2**, there is shown a block diagram of a process for designing, configuring, modifying, and maintaining a sound system for a facility such as shown in

FIG. **1**. Steps involving data collection and input are in the left column. Automated steps are in the center column. Steps that involve human intervention are in the right column. In data collection phase **30**, information about the facility and the desired sound system characteristics is collected. In step **32**, information about the facility is collected and representative signals input to a computer and stored at step **34**. Facility information could include dimensions of the facility and the various listening areas, acoustic spaces, and zones. Facility information could also include the acoustic properties of the several acoustic spaces, and could also include information such as expected level of ambient noise. In step **36**, desired performance properties are collected for each listening area and representative signals input to a computer and stored in step **38**. Desired performance properties for a listening area could include desired maximum and minimum sound pressure level in dB SPL; relative importance of speech or music; aesthetic properties of the sound system; system cost; type of music to be played; system automation properties such as automatic on/off, and other items such as variations from standard components, existing equipment with which the system must operate, and nonstandard material or labor costs. Steps **32** and **36** and the specific activities included in steps **32** and **36** may be performed in any order.

The steps of the data collection phase **30** may be performed in a conventional manner. Data input signals may be facilitated by an appropriate graphical user interface as shown in FIG. **3**. The data collected and signals input in steps **32**, **34**, **36**, and **38** may be stored in a data base that is accessible by the computer (which will be discussed later) of system design phase **40**.

The system design phase **40** includes a component selection and system enhancement step **42**. In the component selection and system enhancement step, the information input signals in the data collection phase are compared with the signals representative of properties of various sound system components (such as amplifiers, loudspeakers, and electronics components) to select the components for an enhanced sound system. The signals representative of properties of sound system components may be stored in a database that has been previously assembled in step **44** and stored in a computer memory. Information about amplifiers could include number of channels; power distribution capacity (per channel and per amplifier); maximum gain; power requirements; and cost. Information about loudspeakers could include frequency response; coverage efficiency; power requirements; environmental limitations and capabilities; required fixturing; operating range; power rating; maximum rated SPL and cost. Information on the sound system components could also include ancillary features (such as mounting fixtures, wiring, and accessories). The sound system can be enhanced based on several factors, but in a commercial setting, is typically enhanced for cost and performance. The enhancement process will be explained in more detail below. In an optional display step **46**, information about the sound system may be displayed. The information may be displayed in any form useful to the system designer or to others. The display step **46** is particularly useful in a commercial setting to receive customer approval. The steps of design phase **40** are repeated for each of the acoustic spaces in the facility.

Another phase in the system design phase is the document generation step **49**, in which various documents are generated. The documents may include a bill of materials (BOM); a layout of the placement of speakers in the room; a wiring diagram; a block diagram showing the interconnections and logical arrangement of amplifiers, loudspeakers, and other

components; and other documents that may be useful (such as documents for commercial purposes).

In the documentation generation step **49**, information signals stored in the various databases is extracted and used to create the various documents. The BOM is assembled using information signals previously stored in the sound system component properties database combined with the specific components selected in system design phase **40**. The layout and the wiring diagram are assembled using information collected at step **32** combined with the specific system components generated in the system design phase **40**. The layout, wiring diagram, and BOM are generated in real time, that is when the data collection and input steps **32** and **36** are input, a layout and block diagram, and wiring diagram are generated immediately. A layout is displayed on the data input screen, as shown in FIG. **3**. Examples of a BOM and of a block diagram and wiring diagram are shown in FIGS. **4***a* and **4***b*, respectively.

The real time generation of the layout, block diagram, and BOM is very advantageous, because it enables a sound system designer to immediately display an enhanced sound system to a customer, and if necessary, discuss performance/cost tradeoffs with the customer as soon as the customer's data is input.

The steps of system design phase **40** may be performed by a computer program that will be discussed in more detail below.

The system implementation phase **50** may include installation step **54**, in which the components of the sound system (shown in the BOM) are acquired, and the components are physically installed according to the layout, the wiring diagram, and the block diagram. At step **56** the installed system is equalized, and adjusted.

Step **54** is performed in a conventional manner. A next step may be verification, equalization and adjustment at step **56**. Verification is typically performed using acoustic measuring equipment to verify that the system performs as designed, for example radiates the sound pressure level and has the frequency response for which it was designed. Equalization may be done by many conventional means, or by automated means.

If the system designer changes the sound system, or if there is major maintenance on the sound system, the process of FIG. **2** may be performed again, so that the configuration generated and stored at step **42** always has an up-to-date configuration of the system.

In one implementation, the steps of data collection phase **30** and design phase **40** may be performed with the aid of computer program running on a personal computer. The personal computer may be a portable computer, so it can easily be taken to the site of the facility. Additionally, the same computer may be provided with a microphone and a frequency response measuring device and used for the equalization portion of step **56**.

Referring to FIGS. **5***a* and **5***b*, there is shown a class diagram of a computer program for performing the steps in design phase **30** and configuration phase **40**. The model, including syntax, notation, and conventions is consistent with Universal Modeling Language as described in Fowler, "UML Distilled" second edition, ISBN 78021 657838 and Gamma, et. al., "Design Patterns", ISBN 0201633612.

Class definitions and discussions follow. The class names are capitalized to distinguish them from nonclass elements having the same name. For example, "Acoustic Space" refers to a class; "acoustic space" refers to the physical entity defined above.

Business Model **100** is a facade (see "Design Patterns", p. 185) that interfaces with other programs. Business Model **100** may contain Optimizer **101**. The classes contained by Business Model **100** fall into two spaces, a solutions space **161** and a requirements space which includes the remainder of the classes contained by Business Model **100**. Classes in the requirements and resources space represent classes that define the desired properties of the sound system. Classes in solutions space **161** include classes that contain the loudspeaker systems and amplifiers that are available, and the configurations of loudspeakers and amplifiers that meet the properties defined in the properties space.

Enhancer **101** is a service module that assembles multiple sound system configurations and evaluates or optimizes them. Enhancer **101** is described in more detail in FIG. **7**.

The physical representation of Facility **110** was defined above, in the discussion of FIG. **1**. In the context of the program, it is contained by Acoustic Spaces **120** and Listening Areas **130** and may contain Facility Information **111** Facility Electronic Control **113**, Facility Electronic Source **114**, Candidate Amplifier **115**, Scheduled Event **116**, and Control Zone **117**. A Facility may contain Facility Information **111**.

Facility Classes:

Facility Information **111** refers to identifying information about the facility, such as address, owners name; the Facility Information class may also be used to record similar information that refers to other classes.

Facility Electronic Control **113** and Facility Electronic Source **114** each have two components, a desired properties component and a solutions component. The Facility Electronic Control **113** and Facility Electronic Source **114** represent a summation of the Listening Area Electronic Control **134** and Listening Area Electronic Source **135** classes respectively, and will be discussed in more detail below.

Candidate Amplifier **115** holds a number of amplifier identification and specifications for use by enhancer **101** to configure sound systems. Candidate amplifiers may be arranged so that one amplifier is preferred above other amplifiers. For example, a user may wish to prefer a candidate amplifier for reasons other than how well its capabilities match the objectives. A particular amplifier, for example, may be more readily available or significantly less expensive.

Scheduled Event **116** is a master list of Scheduled Events **136** that are specified at the listening area level. Scheduled Event **136** is described below.

Control Zone **117** is a plurality of loudspeakers that could be serviced by a common amplifier. Loudspeakers may be serviced by the same amplifier if they are to receive a common acoustic signal, and if they operate on a common voltage and wattage. A control zone does not take into account the capacity of the amplifier.

System Configuration **118** is a collection of amplifiers and groups of loudspeakers. System configuration also contains Loudspeaker Configurations **119**. System configuration will be discussed later in the discussion of FIG. **5***b*.

Loudspeaker Configuration **119** contains a grouping of loudspeakers. Loudspeaker configuration will be explained in more detail in the discussion of FIG. **5***b*.

The physical representation of Acoustic Space **120** was described above. In the context of the program, an Acoustic Space **120** contains Candidate Loudspeakers **125**, Appearance Preferences **121**, Acoustic Attributes **122**, Geometric Attributes **123**, and System Objective Function **124**.

Acoustic Space Classes

Appearance Preferences **121** refers to appearance features of the loudspeakers, such as color, wall or ceiling mounted, and others.

Acoustic Attributes **122** contains the acoustic features that define the acoustic space.

Geometric Attributes **123** is a list of the geometric features, such as the shapes of the surfaces that constitute the acoustic space. The dimensions of acoustic spaces that were input in step **32** of FIG. **1** may be included in this class.

System Objective Function **124** is a function that places values on the objectives for the sound system for the acoustic space, and compares the objectives with the capability of the proposed sound system to determine how well the proposed sound system meets the objectives. The system objective function may allow weightings, so that, for example, in one situation coverage uniformity may be weighted more heavily than loudness.

Candidate Loudspeaker Systems **125** holds a number of loudspeaker system identifiers with specifications for use by Optimizer **101**.

The physical representation of Listening Area **130** was defined above, in the discussion of FIG. **1**. In the context of the program, Listening Area **130** is contained by Facility **110**. In other embodiments, a Listening Area **130** may be contained by Acoustic Space **120**, or Listening Area **130** may represent common physical entities. A Listening Area may contain Electronic Source **135**, Scheduled Event **136**, and Receiver Region **137**, Listening Area Information **131**, Listening Area Requirements **132**, Acoustic Measures **133**, Electronic Control **134**, Acoustic Objective Function **139**, and System Features **140**.

Listening Area Classes

Listening Area Information **131** is descriptive information about the listening area.

Listening Area Preferences **132** is the sound system preferences for the listening areas. Examples are frequency range capability in the bass range, sound coverage uniformity (in standard deviations), loudness, and the like. Listening Area preferences may contain nonacoustic preferences, such as appearance. The system preferences that were input in step **36** may be included in this class.

Acoustic Measures **133** is the acoustic objectives for that listening area and the actual measurements for those factors. Examples are sound pressure level, bandwidth, and frequency response.

Electronic Control **134** and Electronic Source **135** each have each have two components, a preferences component and a solutions component. Listening areas may be a part of the customer preferences. For example, a customer may want a tuner and satellite television source in a listening area, and are therefore part of the preferences space. Providing a tuner and a satellite television source fulfills the preference, and is therefore in the solutions space. Similarly an electronic control element, such as a wall switch for turning the electronic components on and off may be both a preference and a solution.

Scheduled Event **136** is an event that automatically occurs at a specific time. Examples are system power on/off and volume setting change.

Receiver Region **137** contains the Point Listener **138** class.

Point Listener **138** is a point in a listening area that is used to determine system performance. Receiver Region **137** and Point Listener **138** are discussed in more detail in FIG. **6**.

Acoustic Objective Function **139** is a function that places values on the objectives for the sound system for the acoustic space, and compares the objectives with the capability of the proposed sound system to determine how well the proposed sound system meets the objectives. The system objective function may allow weightings, so that, for example, in one situation coverage uniformity may be weighted more heavily than loudness.

System Features **140** are capabilities such as automatic volume control, remote control capability, and the like that are required for the listening area.

Referring to FIG. **5**B, there is shown the classes of solutions space **161** in more detail. System Configuration **118** and Loudspeaker Configuration **119** in more detail. System Configuration **118** contains Amplifier **201**, Amplifier Model Lot **202**, and Loudspeaker Configuration **119**, Performance **203** and Penalties **204**. System Configuration **118** is the loudspeakers, loudspeaker settings, amplifier and amplifier settings in the sound system.

Amplifier **201** is contained by System Configuration **118** and Amplifier Model Lot **202** and contains Amplifier Channel **205**. This class represents specific amplifiers to be used in a system configuration. The amplifier properties, including identification data and specification sheet data that were assembled in step **44** may be included in this class.

Amplifier Model Lot **202** is a grouping or collection of amplifiers in a System Configuration.

Performance **203** is a measure of the System Configuration **118** capabilities relative to the performance objective criteria that were set for the sound system.

Penalties **204** is used in evaluating potential system configurations. Penalties may be assigned to specific shortcomings, and may be used to accomplish the weightings in Acoustic Objective Function **139** and System Objective Function **124**.

Amplifier Channel **205** contains Loudspeaker **211** and Loudspeaker Model Lot **212** and is contained by Amplifier **201**. Amplifier Channel **205** is typically one of the channels in a multichannel amplifier.

Loudspeaker Configuration **119** is contained by System Configuration **118** and contains Loudspeaker Model Lot **212** and Acoustic Measure Record **213**.

Loudspeaker **211** is a specific loudspeaker. Loudspeakers may be specified as model numbers, and typically have specified capabilities and characteristics (voltage and wattage ratings and the like). The amplifier properties, including identification data and specification sheet data that were assembled in step **44** may be included in this class.

Loudspeaker Model Lot **212** is a grouping or collection of loudspeakers.

Acoustic Measure Record **213** is contained by Loudspeaker Configuration **119** and contains Measures **214** and Penalties **215**.

Measures **214** is a measure of how well the capabilities of the Loudspeaker Configuration **119** relative to the performance criteria that was set for the sound system.

Penalties **215**, similar to Penalties **204**, is used in evaluating potential loudspeaker configurations. Penalties may be assigned to specific shortcomings, and may be used to accomplish the weightings in Acoustic Objective Function **139** and System Objective Function **124**.

A software program for implementing the software architecture of FIGS. **5***a* and **5***b* is included as Supplementary Disk A. The program is designed to run on the Windows 2000 operating system, running on a standard laptop personal computer.

Referring now to FIG. **6**, there is shown a hypothetical listening area **70** for the purpose of explaining Point Listener **138** and Receiver Region **137**. Sound for listening area **70** is provided by loudspeakers **72**, **73**, and **74**, which receive an audio signal from amplifier **76**. Mathematically, the listening area is overlaid with a grid **78**. The intersections **80** of the grid lines represent points correspond to the points associated with Point Listener class **138**. The direct field radiation from loudspeakers **72**, **73** and **74** at each intersection **80** is determined. Data from the several points are combined to obtain a receiver region, which corresponds to Receiver Region class **137**. If polar plots for the loudspeakers **72**, **73**, and **74** are available, the polar plot is taken into account when determining the direct field radiation. In other embodiments of the invention, more complex techniques, such as including reverberant field radiation, for determining a sound field could be used. These techniques may give somewhat more precise estimations of the sound field using more computational power.

Referring now to FIG. **7**, there is shown a logical diagram of Enhancer **101**. Initial assessment logic **60** receives from Listening Area Preferences **132** the sound system preferences, from Acoustic Attributes **122** the acoustic features, from Geometric Attributes **123** the geometric features, and from Candidate Loudspeaker Systems **125** a number of candidate loudspeaker systems for initial assessment. If the total number of potential candidate loudspeaker systems is small, all potential candidate systems may be submitted to initial assessment logic **60**. If the total number of potential candidate loudspeaker systems is large, a subset of the total number of potential candidate loudspeaker systems may be selected based on predetermined rules. Initial assessment logic **60** performs a rules-based first assessment of the candidate system vis-à-vis the preferences and attributes, discards the incompatible systems, and forwards the compatible candidate configurations to layout logic **62**. Layout logic **62** develops a layout (according to rules) for each of the compatible candidate configurations, and forwards the layout to simulation logic **64**. Simulation logic **64** simulates the layout (using Receiver Region **137**) of the compatible candidate configurations and forwards the simulation results (that is, the results of the process described above in the discussion of FIG. **6**) to Evaluation Logic **66**. The layout may be modified and cycled through layout logic **62**, simulation logic **64**, and layout evaluation logic **66** until the layout for each candidate layout is enhanced. The enhanced layout for each candidate is then forwarded to configuration logic **68**, which combines the enhanced layouts with candidate amplifiers from Candidate Amplifier **115** that are suitable to power the loudspeaker configuration. In the event that there is more than one candidate amplifier, the system evaluator logic **70** selects a preferred enhanced system configuration. Preference may be done based on a number of factors, but typically the preferred configuration is the lowest priced configuration that meets the desired performance criteria. Rules that are used in initial assessment, selection of candidate loudspeaker systems, and layout logic may be rules that are stated in published guides to sound system design, or may be rules that have been devised by the system designer.

The enhancer may assemble the data for the BOM, layout, and wiring diagram. The BOM, layout, and wiring diagram can be displayed as in FIGS. **4***a* and **4***b*, using conventional graphical display techniques.

Another operation of the configuration Enhancer **101** is the evaluation of manually created configuration. A manually determined configuration is simulated by simulation logic **64** and evaluated by the evaluation logic **66** and determined to either meet or not meet requirements.

It is evident that those skilled in the art may now make numerous uses of and departures from the specific apparatus and techniques disclosed herein without departing from the inventive concepts. Consequently, the invention is to be construed as embracing each and every novel feature and novel combination of features present in or possessed by the apparatus and techniques disclosed herein and limited only by the spirit and scope of the appended claims.

What is claimed is:

1. A method for designing a sound system for a facility, comprising:

inputting performance data signals representing desired performance properties for said sound system to a computer processor;

inputting acoustic data signals representing acoustic characteristics of acoustic spaces in said facility to said computer processor;

comparing, by said processor, said acoustic data and said performance data signals with preexisting stored sound equipment signals representative of sound equipment component capabilities; and

generating, by said processor in real time, a configuration output signal for said sound system representative of a desired sound system.

2. A method for designing a sound system in accordance with claim **1** wherein said output signal includes a component representative of a bill of materials for said desired sound system.

3. A method for designing a sound system in accordance with claim **1**, wherein said output signal includes a component representative of a block diagram for said desired sound system.

4. A method for designing a sound system in accordance with claim **1**, wherein said output signal includes a component representative of a layout for said desired sound system.

5. A method for designing a sound system in accordance with claim **1**, wherein said computer processor is a portable computer.

6. A method for designing a sound system in accordance with claim **1**, further comprising,

repeating the steps of claim **1** to provide a second output signal representative of another desired sound system, and

evaluating, by said processor, said output signal and said second output signal according to predetermined criteria.

7. A method for designing a sound system for a facility in accordance with claim **1**, further comprising:

repeating said inputting performance data signals, said inputting acoustic data signals, and said comparing to provide a second output signal representative of another desired sound system;

evaluating, by said processor, said output signal and said second output signal according to predetermined criteria, wherein said predetermined criteria include a plurality of factors, and wherein said plurality of factors is weighted.

8. A method for designing a sound system for a facility, comprising:

inputting performance data signals representing desired performance properties for said sound system to a computer processor;

inputting acoustic data signals representing acoustic characteristics of acoustic spaces in said facility to said computer processor;

comparing, by said processor, said acoustic data and said performance data signals with preexisting stored sound equipment signals representative of sound equipment component capabilities; and

generating, by said processor in real time, a configuration output signal for said sound system representative of a desired sound system,

wherein said output signal includes a component representative of a component from the group comprising a bill of materials for said desired sound system, representative of a block diagram for said desired sound system, representative of a layout for said desired sound system, and said computer processor is a portable computer,

repeating the steps of inputting performance data signals representing desired performance properties for said sound system to said computer processor, inputting acoustic data signals representing acoustic characteristics of acoustic spaces in said facility to said computer processor, comparing by said processor, said acoustic data and said performance data signals with pre-existing stored sound equipment signals representative of sound equipment component capabilities, and generating by said computer processor in real time, a second configuration output signal for said sound system representative of another desired sound system, and evaluating by said processor, said output signal and said second output signal according to predetermined criteria,

wherein said predetermined criteria include a plurality of factors, and wherein said plurality of factors is weighted.

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